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Technical Memorandum 11-69

A STUDY OF CALL PROCESSING ON THE

AN/TTC-15M SWITCHBOARD

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August 1969
AMCMS Code 4610.000

HUMAN ENGINEERING LABORATORIES

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SUBJECT: Transmittal of Changes to Technical Memorandum 11-69

The following pen and ink changes will be made to correct minor deficiencies:

a. Page 13, Table 3, make notation that call-processing times are shown in seconds.

b. Page 16, Table 6, make notation that call-processing times are shown in seconds.

c. Page 24, line 1, "Appendix H" to read "Table 6."

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ABSTRACT

This report covers the second in a series of studies directed towards analyzing the operator call-processing efficiency of a new family of cordless manual switchboards currently within the Army's inventory. Subjects were required to process a battery of 50 simulated calls of various types in each mode of operation. Call-processing time and operator error were measured and later integrated into actual tactical telephone traffic data for analysis.

CONTENTS

APPENDIXES

FIGURES

TABLES

A STUDY OF CALL PROCESSING ON THE

AN/TTC-15M SWITCHBOARD

INTRODUCTION

Background

A new family of cordless manual switchboards is currently under development by the Random Access Discrete Address/Tactical Automatic Switching Project Manager's Office (RADA/TAS PMO). Exactly how much more efficient these new cordless manual switchboards will be has yet to be determined, since they still are in the developmental stage. In order to get some idea of their relative efficiency before field testing, the U. S. Army Human Engineering Laboratories (HEL) were asked to help evaluate their operator call-processing efficiency. One such cordless manual switchboard, the SB-3082( )/GT has already been evaluated (2). This report continues with the task by evaluating the operator call-processing of another cordless manual switchboard, the AN/TTC-15M.

Item Description

The AN/TTC-15M switchboard is a second generation development of the AN/TTC-15. The AN/TTC-15M switchboard is presently envisioned as having a 60-termination capacity expandable to 120 when additional printed wiring boards are installed. These terminations can be local or trunk, two-wire or four-wire telephone circuits. The switchboard will have two operators' positions and be mounted in an S-250 shelter.

In operation, all calls come to the operator(s) in a single queue at each operator's position. Connections are made by the operator selecting the desired called party's number on a pushbutton keysender. Disconnects are automatic, requiring no action on the part of the operator. The conditions of any termination, i.e., busy, idle, or priority busy, are presented in both audio and visual feedback when that number has been selected on the keysender. The keysender can also be used for keying multifrequency digits or for generating DC dial pulses, as appropriate, for interoperation with other switching systems. Additional details of the AN/TTC 15M are found in Appendix C.

Objectives

In the evaluation of the AN/TTC-15M, four primary objectives were identified:

1. What are the effects on operator call processing capabilities as the switchboard increases in termination capacity?

2. What is a realistic call-processing time for an average operator on the AN/TTC-15M?

3. How does the AN/TTC-15M compare with present standard manual switchboards, such as the SB-86/PT?

4. How does the AN/TTC-15M compare with other cordless manual switchboards, specifically the SB-3082( )/GT?

METHOD

Basic Approach

The basic approach used to answer the questions in the operator call processing evaluation of the AN/TTC-15M can be broken down into two stages:

1. Functional/Time Tests: Following training as AN/TTC-15M switchboard operators and acclimatization to a pseudo tactical communications environment, each subject processed simulated traffic through a model AN/TTC-15M under three operating conditions:

a. A single operator, 50-termination capacity situation with 18 Local Battery (LB) calls placed in the call sequence (50 LB Test).

b. A single operator, 50-termination capacity situation with no Local Battery calls (50 Test).

c. A single operator, 100-termination capacity situation with no Local Battery calls (100 Test).

The 50 LB Test measured only errors in the 18 local battery calls and served as a warm-up condition.

In all three conditions, the termination capacity used was below the maximum capacity (60-120) of which the AN/TTC-15M is capable. This procedure was followed to reduce variance among the AN/TTC-15M, SB-3082 ( )/GT and SB-86/PT Tests. A double-operator situation was not tested.

2. SB-3082( )/GT an SB-86/PT Functional/Time Comparative Analysis: The results of similar functional/time tests previously conducted on the SB-3082 ( )/GT

Cordless Manual and SB-86/PT Manual Switchboards (2) were compared with those of the AN/TTC-15M.

Subject Selection

Nine enlisted personnel from the 325th Signal Battalion, Fort Meade, Maryland, were used as subjects. All were school-trained switchboard operators who had operating experience with the manual switchboards currently in the Army's inventory. These subjects were drawn from the same population used in earlier switchboard studies (2).

Test Environment

The simulated test environment used in this study was the same as that used with the SB-3082( )/GT and SB-86/PT (2). The actual fluid tactical communications environment produces an extreme number of variables that defy standardization under any single study. Several of these variables were therefore reduced to controllable increments while others were fixed during testing, to be replaced later by more meaningful data collected from actual tactical traffic data. The prime consideration in designing the test environment was to obtain realism and a common base for all tests.

Test Location

The tests were conducted under controlled conditions of temperature, light and noise to exclude extraneous factors from the call-processing time data. All subject/operators performed under the same conditions.

Call-Processing Considerations

Rather than attempt to inject all possible call combinations into the test, only nine basic call types were used. This allowed subject/operators not only to experience the problems of handling more than just normal or normal/busy call traffic but also provided reliable data on other types of calls. The basic nine were:

1. Normal (N): Calling party requests called party under routine precedence: call extended.

2. Normal Busy (NB): Calling party requests called party under routine precedence: called party busy; calling party must recall later.

3. Dial (D): Calling party requests called party under routine precedence on dial circuit: call extended.

4. Keysender (K): Calling party requests called party under routine precedence on keysender circuit: call extended.

5. Conference (C): Calling party requests conference call with several parties under routine precedence: call extended.

6. Information Service (I): Calling party requests called party by other than standard designation: operator locates, informs calling party of called party's number, and extends call.

7. Priority (P): Calling party requests called party under priority precedence: call marked priority and extended.

8. Priority Pre-empt (PP): Calling party requests called party under priority precedence: called party routine busy; routine call pre-empt and priority call established.

9. Priority Busy (PB): Calling party requests called party under priority precedence; called party priority busy; operator interrogates to determine level of priority, and pre-empts if necessary.

Each test (50LB, 50 or 100) used the same call sequence (Table 1a, 1b). Each test consisted of simulating 50 calls placed to the operator in as rapid a succession as he could handle them. Roughly five calls were always waiting in queue. The subject/operator was not informed of the quantity of calls to be processed nor of the fact that their distribution was the same in each test. Each subject was told only that he would be handling a battery of call requests and that there would be no idle time between calls. The amount of each call type included was based on projected estimates of call traffic with at least three of each call type included.

Since operator call processing times included speaking time, a standard call-processing format was established for each type call to promote a high degree of operator proficiency and simulate optimum subscriber training (Appendix A). In setting up the standard call processing format, the following assumptions were made:

1. Ruthless pre-emption was considered as a standard operating procedure.

2. Seven-digit numbers were used in all Keysender and Dial calls with the first three digits being the same each time. Peculiar to the AN/TTC-15M, both K and D calls are processed through a keysender and not a keysender plus dial unit as found in the SB-3082. In all analysis then, D/K calls were grouped together.

3. Conference calls consisted of only normal call types; i.e., no Keysender, Dial, Normal Busy, etc., conference parties were included. Each conference call was a four party call (originator + 3). Each conferee's number was allowed to ring twice before answering.

TABLE 1

a. Call Sequence

Call Number	1	2	3	4	5	6	7	8	9	10
1-	N	NB	D	P	NB	N	I	N	PP	D
11-	N	PP	PB	N	I	P	K	P	N	I
21-	C	NB	K	N	PB	N	N	P	N	N
31-	PP	P	D	C	N	I	I	PB	NB	N
41-	K	NB	I	N	C	N	N	I	N	N

b. Totals Per Call Type

N-18	C-3	PP-3
NB-5	I-7	PB-3
D/K-6	P-5	

6. In the handling of all calls (except Conference Calls) where a ring forward is required, a standard operating procedure of "forward and forget" was followed. During peak traffic periods the policy of "forward and forget" is reasonable to assume, since operators would seldom have time to stay with a call until the called party answers under such conditions.

7. A mixture of Local Battery (LB) and Common Battery Signaling (CBS) was studied in the 50 LB Test.

Switching Network Environment

A division common-user telephone switching network, following current doctrinal guidelines, was selected for the simulated switching-network environment in which the testing would take place. For the 100 test Division Main Switch was chosen as the test site; for the 50 and 50LB tests, a Brigade Switch location was chosen. The switching network and test sites having been selected, appropriate trunking diagrams termination assignments and alphabetical directory lists, were prepared for the two tests (Appendix B). Also, test schedules were prepared which provided the tester with the necessary forms to control the conduct of the test and to serve as data collection forms (Appendix B).

APPARATUS

Switchboard Simulator

At the time that the AN/TTC-15M Functional/Time Tests were being planned, an actual working unit of that switchboard had yet to emerge from the drawing board. The contractor, however, had constructed a partial, non-functional switchboard model for demonstration purposes which, with some minor additions, provided satisfactory audio and visual realism for the purposes of this study (Fig. 1). (Appendix C gives the details of the switchboard simulator operation.)

Event Recorder

Call-processing times were measured using an Esterline-Angus Operation Recorder with a timed advance. The event recorder was activated by the Call Advance Switch. In all three tests, as the subject pushed the Call Advance Switch to sever himself from the call he had just finished processing and connect to the next call in queue awaiting service, the action would be marked. Each call was measured from initial operator action on the call request to completion of the last operator function in forwarding that call, excluding any overlap from the preceding call. This is the same call processing time measuring criteria as used in the tests conducted previously on the SB-3082( )/GT and SB-86/PT switchboards (2).

Intercommunications Equipment

To permit both the subject/operator and test-control personnel to receive the audio feedback from the switchboard simulator and to allow the test-control personnel and subject/operator to converse, TA-312/PT field telephones were used in conjunction with H-91 headsets to establish an intercommunications system (Fig. 2). For example, in a Conference Call, both the remote-control attandant and the subscriber/monitor could hear the conferees being rung -- the remote-control attendant so that he could determine when a conferee's number has rung twice and released, and the subscriber/monitor -- so that he would know when to answer the ring as a conferee.

TESTING PROCEDURE

Pre-Test Considerations

First, the subjects were thoroughly acquainted with the procedures of the study. After this initial briefing, they underwent an intensive training program, including

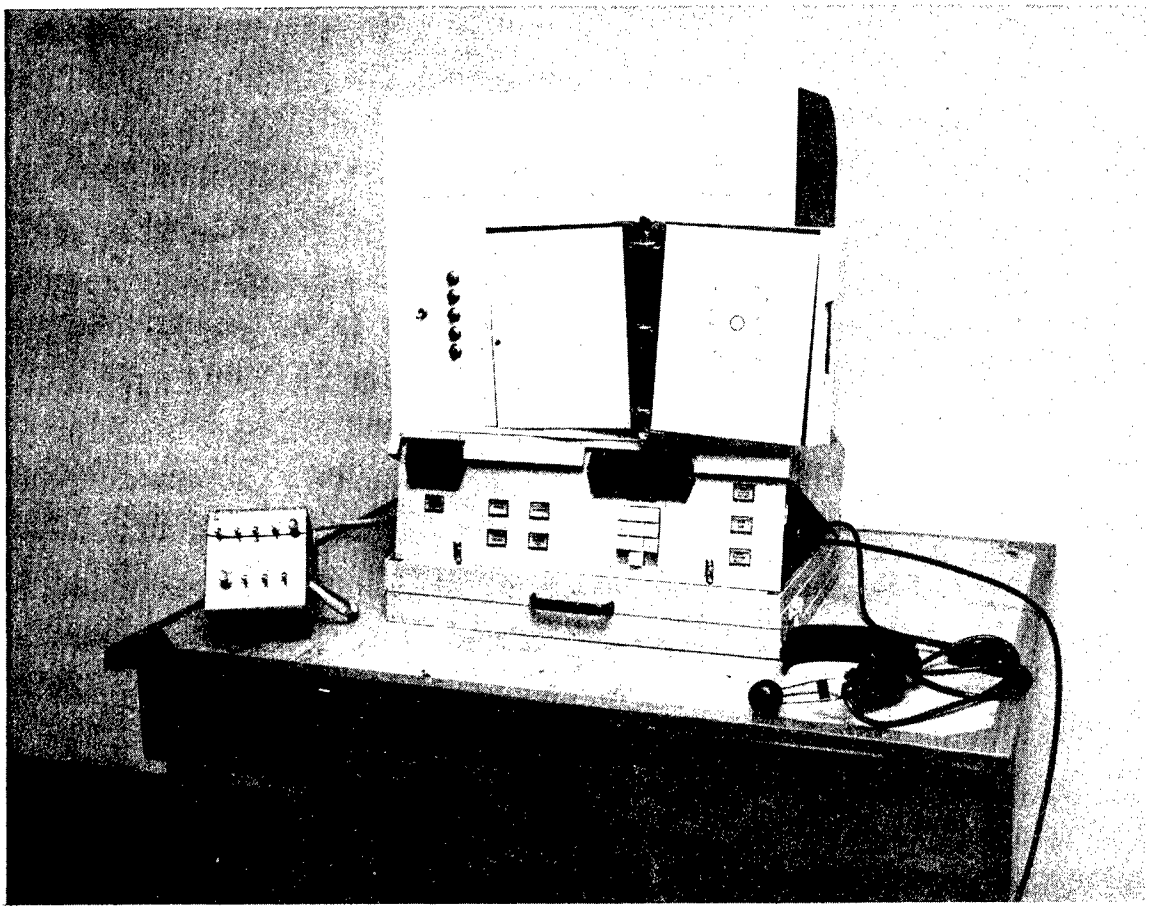

Fig. 1. AN/TTC-15M SWITCHBOARD SIMULATOR

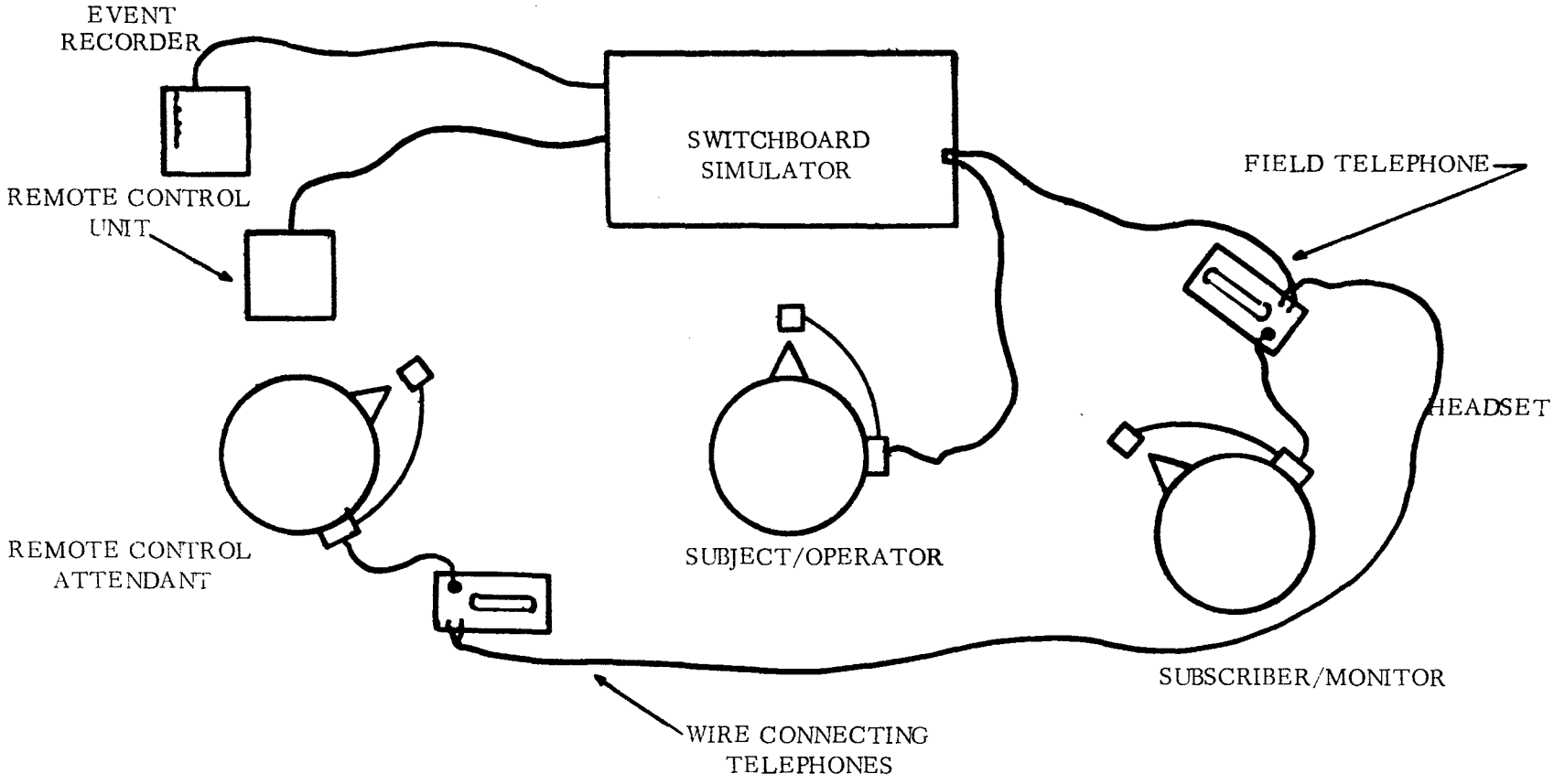

Fig. 2. TEST APPARATUS ARRANGEMENT

indoctrination in proper call processing format and extensive practice with the test apparatus. This training was directed at bringing the subjects to comparable levels of performance. No attempt was made to establish peak efficiency since the goal of the study was to test the capability of the equipment rather than the relative efficiency of the subjects.

The complete test schedule is outlined in Table 2.

TABLE 2

Testing Schedule

1. General orientation
2. Introduction to apparatus
3. Briefing on simulated communication's environment--Brigade Switch location
4. Explanation and walk-through of call processing procedures
5. Practice of call processing procedures
6. 50 Test
7. Critique
8. Briefing on simulated communication's environment -- Division Main Switch location
9. 100 Test
10. Critique and Summary
11. Questionnaire

Test Conduct

Two individuals were required to conduct the tests: the Remote Control Attendant and the Subscriber/Monitor (Fig. 2). The Remote Control Attendant had three tasks:

1. To operate the event recorder.

2. To mark the test being conducted on the recording paper.

3. To operate the remote-control unit to augment conference and priority-call simulation (see Appendix C for details).

The Subscriber/Monitor performed two functions:

1. Observe subject errors during the test and record them on the test schedule.

2. Use the same test schedule to play the subscriber role(s).

QUESTIONNAIRE

At the completion of the testing, subject/operator comments on the AN/TTC-15M were solicited via a prepared questionnaire (Appendix D). Opinions were sought on call-handling procedures, comparison of operating modes, front-panel layout design, physical characteristics of controls, and comparison to the SB-86/PT switchboard.

RESULTS AND DISCUSSION

The Results and Discussion Section is divided into four elements, an introduction to the section, Quantitative Call Processing Time Analysis, Error Rate Analysis, and Questionnaire Response Analysis. For the latter three elements, the results and discussion for each is discussed separately.

Objectives 1 and 2 are met by data collected in this study. The other objectives involve data previously collected from tests on the SB-3082( )/GT and SB-86/PT switchboards (2). This extrinsic data is necessary to meet two of all test objectives formulated in the Introduction to this report.

a. Objective two: To compare the AN/TTC-15M switchboard to the manual switchboards now being used by the Army, such as the SB-86/PT.

b. Objective four: To compare the AN/TTC-15M switchboard to other cordless manual switchboards; specifically, the SB-3082( )/GT switchboard.

To compare the AN/TTC-15M with the other switchboards, similar test operations were paired and analyzed:

1. AN/TTC-15M vs SB-3082( )/GT: The following test data were extracted from HEL Technical Memorandum 1-69 (2):

a. Test 1A: One operator, 50-terminal capacity, automatic mode of operation.

b. Test 2A: One operator, 100-terminal capacity, automatic mode of operation.

Comparisons between test 1A (SB-3082( )/GT) and 50 (AN/TTC-15M), and between test 2A (SB-3082( )/GT) and 100 (AN/TTC-15M) are made.

2. AN/TTC-15M vs SB-86/PT: As is the case with the SB-3082( )/GT, the AN/TTC-15M is a cordless-manual switchboard and of prime interest are comparisons relating the new switchboard to present cord-type boards, such as the SB-86/PT. The SB-86/PT was tested only in the single-operator, 50-line capacity mode.

Quantitative Call Processing Time Analysis

Results

The call processing data is presented in three ways: normal, composite, and individually by call type. Normal is a specific group consisting only of N call types. Composite is a group of all nine call types and is computed in the following manner:

a. For each subject under each mode an average call processing time is determined for each call type.

b. This average is multiplied by the number of calls of that type that are occurring in the test sequence of 50 calls (Table 1b). This number will usually, but not necessarily, be the number of calls on which the average is based. This was because calls in which errors were committed were excluded from time analysis.

c. These nine products, one for each call type, are summed.

d. This sum is divided by 50 -- the number of calls in the composite call sequence.

Normal and composite is the principle method by which the call processing data was compared. This gives a comparison of two hypothetical traffic compositions, rather than individually by call type. These two specific traffic composition conditions were chosen to represent a simplified traffic situation (normal) and a complex traffic condition (composite) for analysis. A preliminary survey of actual traffic data (4) indicates that present subscriber calling characteristics fall more in line with the normal group. This is probably because the present cord-type manual switchboards make the specialized call types (conference, priority, etc.) too complex or time consuming. Other call types, such as keysender, have not had too much application in a tactical communications environment as of this date. Comparing the two groups (normal and composite) gives an indication of the overall effect of introducing these specialized call services.

Table 3 presents average call processing times by mode of operation (1a, 2A, SB-86, 50, 100 tests) for both normal calls and the composite call sequence. Error times were excluded. The basic data was subject average call processing times rather than individual call processing times. Standard deviations and ranges are also given.

Table 4 presents the results of a "percent reduction" analysis. In this analysis the call-processing time in a base mode is compared to that of an alternative mode to produce a performance comparison. The basic computational form is:

$$\frac{\text{Base Time - Alternate Time}}{\text{Base Time}}$$

TABLE 3

Grand Averages, Standard Deviations, and Ranges of Call-Processing Times

	Normal				Composite			
		Standard	Range			Standard	Range	
	Average	Deviation	Min	Max	Average	Deviation	Min	Max
AN/TTC-15M								
50	5.0	.5	4.1	5.9	10.4	1.6	8.1	12.8
100	5.1	.4	4.4	5.6	11.5	1.1	10.6	14.0
SB-3082								
1A	6.3	1.6	4.6	6.9	14.1	1.5	12.0	16.3
2A	6.7	2.5	5.3	7.9	14.7	1.6	12.6	17.4
SB-86								
	18.2	2.3	15.8	22.0	25.4	2.5	21.1	28.6

TABLE 4

Percent Reduction in Normal Call-Processing Time Summary

	Averages	
	Normal	Composite
(1A-50)/1A	20.63%	25.71%
(2A-100)/2A	23.89%	21.77%
(100-50)/100	1.96%	3.36%
(86-50)/86	72.53%	59.06%

Using this computational form, it can be seen that if the alternate time is half the base time, a 50 percent reduction is the result. Presented in this table are averages and ranges based on the individual computations shown in the Master Data Sheets.

Table 5 presents the results of a "between Groups" analysis using the standard "t" test. The hypothesis tested is that if the absolute value of the "t" statistic is less than or equal to the tabular value, for the appropriate degrees of freedom, at alpha = .025; then, the two groups tested are statistically the same. The notations listed under RELATIONSHIP indicate the statistical relationship between the two groups being tested.

Table 6 presents the average, standard deviation, and range of call-processing times by call type.

Discussion

AN/TTC-15M, 50 vs 100: The primary difference in these two conditions was in their directory lists. The directory list for the 100 Test was spread over four pages in order to test the effect of conducting an information search in a multiple-page directory. For the 50 Test, all information was displayed on one visible surface.

Since there was no difference in the call-processing procedures of 50 and 100 test and only one relatively minor difference in the alphabetical directory, it would be expected that the call-processing times would be nearly the same, with possible slight increases for 100 line Information calls. Tables 3 and 4 tend to verify this opinion. The "t" test results of test 4 of Table 5 show that there is no statistical difference between 50 and 100. However, "t" tests were also used to compare the 50 and 100 times of each call type in Table 6. With the exception of PP and I, all call types showed no significant difference. The exceptions, PP and I, were significantly different at the .0005 level. The reason for the PP call type exception could not be determined from data available and reduces the validity of the hypothesis that I call variance is the principle reason for the difference between the 50 and 100 tests.

AN/TTC-15M (50) vs SB-3082( )/GT (1A): The primary differences between these two switchboards is that the SB-3082( )/GT presents the operator with a matrix of 50 line/trunk switches, while the AN/TTC-15M has only a keysender type unit. To establish a normal connection with a given line/trunk, the operator of an SB-3082 ( )/GT must search the switch matrix and then push the appropriate switch. Using the AN/TTC-15M, however, the operator need only key the appropriate three-digit number on the centrally located keysender unit.

In addition to manipulating the multiplicity of line/trunk switches, processing other than normal calls on the SB-3082( )/GT requires the manual manipulation of additional switches and, in some instances, the simultaneous manipulation of two

TABLE 5

"t" Test Summary

Test #	Group I	Group II	Statistic	Critical Value =.025	Significant Difference	Relationship
1.	100 Line (AN/TTC-15M)	50 Line (AN/TTC-15M)	.9756	1.960	NO	I=II
2.	IA (SB-3082)	50 Line (AN/TTC-15M)	7.8315	1.960	YES	I>II
3.	2A (SB-3082)	100 Line (AN/TTC-15M)	6.8610	1.960	YES	I>II
4.	SB-86	50 Line (AN/TTC-15M)	54.6658	1.960	YES	I>II

TABLE 6

Average Call-Processing Times by Call Type
AN/TTC-15M

Call Type	50 Line Average	50 Line Standard Deviation	50 Line Range Min	50 Line Range Max	100 Line Average	100 Line Standard Deviation	100 Line Range Min	100 Line Range Max
N	5.0	.5	4.1	5.9	5.1	.4	4.4	5.6
NB	5.2	.5	4.8	6.1	5.4	.6	4.7	6.3
I	8.6	1.5	5.9	13.9	11.5	1.8	8.9	13.9
P	6.3	1.0	5.0	8.3	7.2	4.0	5.8	9.3
PP	6.6	.8	4.8	7.6	7.9	.8	6.6	8.6
PB	22.0	5.0	15.8	29.4	22.2	1.4	18.3	27.4
C	42.4	6.4	33.7	46.1	41.0	7.2	33.6	45.7
D/K	16.6	5.4	15.8	28.3	17.3	3.6	12.7	22.5

additional switches. This is never the case with the AN/TTC-15M. A single, centrally located keysender unit augmented by six functional switches enables an operator to process just as many diverse calls as does the SB-3082( )/GT. The AN/TTC-15M requires fewer control manipulations and procedural steps to process any given call than does the SB-3082( )/GT.

Inspection of the call-processing procedures (listed in HEL Technical Memorandum 1-69 (2) for the SB-3082( )/GT and in Appendix A of this report for the AN/TTC-15M) shows that call-processing procedures for the AN/TTC-15M are significantly less complicated than those of the SB-3082( )/GT.

Table 3 indicates that, for both normal and composite averages, the call-processing times for the AN/TTC-15M (50) are faster than the times for 1A. The

normal averages indicate that searching a 50-line/trunk matrix takes more time than does keying a three-digit number on a centrally located, keysender unit. Thus, the difference in normal averages can be directly attributed to the line/trunk search on the SB-3082( )/GT. Dissimilarities in call-processing procedures appear to be the determining factor as to the difference in composite times. This difference can be directly associated with the diverse call-processing procedures that the SB-3082( )/GT necessitates for different call types.

Table 4 shows the percent reduction from 1A to 50 and Table 5, Test 2, indicates that this reduction is significant.

AN/TTC-15M (100) vs SB-3082( )/GT (2A): The only difference between Tests 1A and 2A is in the matrix size displayed to the operator. While 1A presents the operator with a 50-termination line/trunk matrix, 2A presents a 100-termination line/trunk matrix. Thus, the operator's search area is doubled in 2A. This being the case, 100 versus 2A presents the comparison of an operation that has essentially the same functions as the 50-line test to another in which the requirements placed on the operator have increased over those imposed by the 50-line test.

Thus, it is expected that call-processing averages for 2A be higher than those of 100. Table 5 indicates this to be so; Table 5, Test 3, indicates that there is a significant difference in the times.

AN/TTC-15M vs SB-86/PT: The results presented in HEL Technical Memorandum 1-69 (2) indicated that the SB-86/PT was far inferior to the SB-3082( )/GT. Tests on the AN/TTC-15M indicates that it is superior to the SB-3082( )/GT; it is therefore logical to assert that the AN/TTC-15M is also superior to the SB-86/PT. All of the data in the tables and appendixes substantiate this assertion.

Error Rate Analysis

Results

As with call-processing times, the errors made by subject/operators during testing were reduced, compiled and analyzed, and they are presented in Tables 7-9. These tables were produced from the Master Data Sheets on error rate found in Appendix E. Errors are pooled over all subjects.

Generally, two types of errors were noted: recalls and delays. Recalls were defined as those errors that would cause the calling party to re-initiate his call. Delays were defined as any error not including recalls that would retard the call-processing procedure: since a recall error has a more serious effect on switchboard operations, the recall rate is shown separately in Tables 7 and 8, whereas delays are included with recalls under the composite grouping of "all errors." The term "normal" in this section denotes those errors that are not related directly to

any particular call type. The term "composite" is used under the same conditions as in the previous section.

Table 7 presents the error rates by mode of operation for the AN/TTC-15M, SB-3082( )/GT and SB-86/PT Switchboard for both normal calls and composite call sequence. Except for the base column, the figures shown are number of errors per 100 calls. The figures in the base column show total calls handled per mode of operation per line. For example, in the 50 Test for the AN/TTC-15M, the subjects committed 0.23 errors per 100 normal calls, and this figure was based on a sample size of 427 normal calls. Figures less than 1.0 are treated as zero.

Table 8 presents the differences in error rates between tests.

In Table 9, error rates for the various switchboards' modes of operation have been averaged and presented for both normal and composite call sequence.

TABLE 7

Error Rate Summary

	Normal		Composite		
	Recalls	All Errors	Recalls	All Errors	Base
AN/TTC-15:					
50 Test	—	—	—	3.28	427
100 Test	—	1.66	—	2.84	422
SB-3082( )/GT:					
1A Test	—	—	2.98	5.79	380
2A Test	—	—	1.85	3.71	377
SB-86/PT:					
86 Test	3.41	5.68	6.25	9.09	176

Note: Except for the base column, figures shown are number of errors per 100 calls. Figures less than 1.0 are treated as zero.

TABLE 8

Error Rate Differences

Test	Normal		Composite	
	Recalls	All Errors	Recalls	All Errors
1A - 50	—	—	2.28	2.51
2A - 100	—	—	1.14	—
86 - 50	3.18	4.74	5.54	5.81
100-50	—	—	—	—

Note: ( ) indicates increase
All figures are errors per 100 calls
Figures less than 1.0 are treated as zero.

TABLE 9

Average Error Rate for All Errors

	Normal	Composite
AN/TTC-15M	1.30	3.06
SB-3082( )/GT	1.12	4.42
SB-86/PT	5.68	9.09

Note: All figures are errors per 100 calls

Discussion

1. AN/TTC-15M, 50 vs 100: There is no basic difference in the call-processing procedures when the AN/TTC-15M is operated in the 50 and 100 modes. This would suggest that error rates in these two modes should be about the same. Tables 7 and 8 confirm this suggestion, indicating that the difference in error rate between these two modes is always less than one error per 100 calls processed.

2. AN/TTC-15M vs SB-3082( )/GT: The AN/TTC-15M appears to require less complicated procedures to process calls than does the SB-3082( )/GT. If this is so, the results should be that less time is required and fewer errors are committed by operators processing calls on the AN/TTC-15M. The Call Processing Time section of Results & Discussion has already shown the AN/TTC-15M is faster; Tables 7 and 8 show that slightly fewer errors are committed by operators using the AN/TTC-15M than operators using the SB-3082( )/GT. The only exception to this is that, in processing normal calls, slightly more non-recall errors are made on the AN/TTC-15M. This can be attributed to the fact that the operator keys a three-digit number to have a normal connection instead of pushing one switch. However, the operator is given immediate feedback as to what number has keyed and can correct his mistake before the erroneous connection is made.

3. AN/TTC-15M vs SB-86/PT: Operations of the AN/TTC-15M is less complicated than operation of the SB-86/PT. The error-rate analysis reflected in Tables 7 and 9 clearly indicates that significantly fewer errors are committed by operators using the AN/TTC-15M than those using the SB-86/PT.

4. Local Battery/Common Battery Signaling Mix: In the 50 LB Test, where the terminals were a mixture of local-battery and common-battery signaling modes (as described in the Method section), error observation was centered on failure to note a local-battery called party. As shown in Table 1E, Appendix E, not one error was made out of 72 possibilities. This indicates that a local-battery/common-battery signaling mixed switchboard of this design should cause little error.

Questionnaire Response Analysis

Results

The collective results of the questionnaire are shown in Appendix G. Subject/operator opinion ratings were compiled and converted into "confidence factor ratings" (CFR) which are summarized in Table 10. CFR equals the sum of the replies times a weighting factor, divided by nine, which was the total number of subjects. Ratings were in terms of ease of conduct/remembering for call processing procedures and ease of manipulation/preference of location for the various controls and displays.

TABLE 10

Confidence Factor Ratings

Call Processing Procedure	Conduct Rating	Remember Rating
1. Normal Call Extend	1.0	1.0
2. Priority Call Extend	.92	.89
3. Priority Call Extend-Pre emption Required	.96	.89
4. Priority Call Extend-Called Party Priority Busy-Precedence Determination Required	.92	.85
5. Keysender & Dial Extend	1.0	.96

Control/Display	Manipulation Rating	Location Rating
1. Lighted Pushbutton Switches (General Comment)	.96	.96
2. Numerical Displays	1.0	1.0
3. Keysender Group	.96	1.0
4. Call Advance Group	.92	.92
5. Call Release (Reset) Swtich	1.0	1.0
6. Pre-empt Switch	1.0	1.0
7. Interrogate Switch	.96	.96
8. 20Hz Ringdown Circuit Switch	1.0	1.0
9. Priority Switch	1.0	1.0
10. Conference Group	.89	1.0

Weighting factors were assigned in the following manner:

EASY	1.0
MODERATELY EASY	.67
MODERATELY DIFFICULT	.33
VERY DIFFICULT	.0

For example, six responses of "easy" (to conduct, remember, manipulate or locate) and three responses of "moderately easy" would yield a CFR of $((6) \times (1.0) + (3)(.67)) \div 9 = .89$.

Discussion

The high confidence-factor ratings reflected in Table 10 indicate that the subject/operators all had favorable opinions concerning the operation of the AN/TTC-15M. All the individuals thought that the idea of immediate feedback concerning the keyed three-digit number was an excellent idea; in fact, two subjects suggested that the same technique be applied to seven-digit dial and keysender numbers.

All nine subject/operators preferred operating the AN/TTC-15M to the SB-86/PT, their general reason being that call-processing procedures are less complicated and easier to remember.

CONCLUSIONS

In the introduction of this report, four study objectives were stated. The following answers to those objectives, based on the results of this study and the experimental design restrictions imposed upon that study, follow:

Objective 1

As the AN/TTC-15M switchboard increases in termination capacity, what will be the effects on operator call-processing capabilities?

Answer

The average switchboard operator will take the same amount of time to process a normal call regardless of the termination capacity. However, under composite traffic loads, as the number of terminations increases, the call-processing time increases. This increase is primarily due to the added time required to search the expanded information display. The average operator will commit about the same number of errors regardless of the termination capacity.

Objective 2

How willl the AN/TTC-15M compare to manual switchboards such as the SB-86/PT, now used in the Army?

Answer

The AN/TTC-15M switchboard is a definite improvement over the SB-86/PT in both call-processing times and error rate. This is substantiated by the opinions of the subject/operators who unanimously felt that the AN/TTC-15M was preferable to the SB-86/PT. The average switchboard operator is 73 percent faster in processing normal calls and 59 percent faster processing calls under a composite traffic load. The average operator makes about six errors per 100 normal calls and nine more errors per 100-call composite sequence on the SB-86/PT than on the AN/TTC-15M.

Objective 3

How will the AN/TTC-15M compare to other cordless manual switchboards such as the SB-3082( )/GT?

Answer

The average switchboard operator will take 21-26 percent less time to process a call using the AN/TTC-15M switchboard than he will using the SB-3082( )/GT switchboard under either all-normal or composite traffic loads. This difference is statistically significant. He will commit slightly less errors using the AN/TTC-15M under composite traffic loads, but, because he must key a three-digit number to complete a normal call instead of pushing just one button, he will commit slightly more errors using the AN/TTC-15M under all-normal traffic loads. However, because he is given immediate feedback as to what number he has keyed, he can correct his mistake before the erroneous connection is completed thus avoiding a time-consuming recall.

Objective 4

What will be a realistic call-processing time for an average operator on the AN/TTC-15M?

Answer

An average operator servicing either 50 or 100 terminations should be able to process a normal call on the AN/TTC-15M in 5.1 seconds. The faster operators will be able average processing a normal call in less than 4.4 seconds, whereas the slower operator will take as much as 6.0 seconds.

However, communication environments are neither static nor exactly equivalent, and normal calls will not make up the majority of traffic in every case. For

this reason, Appendix H has been included to show average call-processing times per call type so that the reader may compile and evaluate his own situation.

SUMMARY

1. This study measured call-processing efficiency of the AN/TTC-15M cordless manual switchboard. It sought to answer basic questions concerning the switchboard's realistic average call-processing time.

2. Nine enlisted individuals, all of them having previous field experience as switchboard operators, served as subject operators. All participated in the same testing program in which they were trained to operate the AN/TTC-15M switchboard and then processed a battery of simulated call traffic three times using a switchboard simulator (one battery of calls to test local-battery signaling procedures, and one battery of calls for each of the two modes of operation of the switchboard).

The time required to process each call, and each error committed, was recorded during the testing.

3. Average operators can be expected to process a normal call in five seconds using the AN/TTC-15M. This is in contrast to the six to seven seconds required by operators to process a normal call on the SB-3082( )/GT, and the 18 seconds required on the SB-86/PT.

4. In regards to the number of terminations being serviced, there is essentially no difference in the speed or accuracy of call-processing on the AN/TTC-15M.

5. Most operators should be able to process normal calls about 25 percent faster using the AN/TTC-15M as compared to the SB-3082( )/GT switchboard, and on the order of 60 to 70 percent faster as compared to the SB-86/PT.

6. Operators will probably commit less than one error (requiring the subscriber to re-initiate his call) in each 100 normal calls processed on the AN/TTC-15M. This is in contrast to an average one error per 100 normal calls committed by operators using the SB-3082( )/GT switchboard, and five errors per 100 normal calls using the SB-86/PT.

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4. U. S. Army Human Engineering Laboratories. An evaluation of SB-86/PT switchboard traffic data collected in Vietnam. Aberdeen Proving Ground, Md., in preparation.

APPENDIX A

STANDARD CALL PROCESSING FORMAT

Normal Call (N)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired party
(_____, please)
(4) Operator keys number
(1) Operator pushes Call Advance switch

Normal Busy Call (NB)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired party
(_____, please)
(4) Operator Keys number
(1) Operator pushes Call Advance switch

Note: Since both calling party and operator would received the busy signal on an NB call, the operator was not required to state that the number was busy, but went immediately on to the next call.

Dial Call (D)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired dial number
(_____,please)
(4) Operator keys trunk number, receives tone, then keys dial number
(1) Operator pushes Call Advance switch

Keysender Call (K)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired Keysender number
(_____, please)

(4) Operator keys trunk number, receives tone, then keys Keysender number
(1) Operator pushes Call Advance switch

Conference Call (C)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired conferees
(I have a conference call for _____, _____ and _____)
(4) Operator moves Conference toggle switch to TALK and notes originator's number
(5) Operator keys first conferee and waits for answer
(6) Subscriber answers
(Yes!)
(7) Operator says
(Please hold sir, I have a conference call from _____)
(8) Subscriber says
(All right)
(9) Repeat steps (5) - (8) for other conferees
(10) Operator says
(Sir, your conference call is ready, go ahead please)
(11) Subscriber replies
(Thank you)
(12) Operator moves Conference toggle switch to "NORM"

(1) Operator pushes Call Advance switch

Information Call (I)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired party
(Let me talk to the _____ please)
(4) Operator locates number and replies
(The number of the _____ is _____ sir; I'll connect you now)
(5) Subscriber says
(Thank you)
(6) Operator keys number
(1) Operator pushes Call Advance switch

Priority Call

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator

(3) Subscriber indicates desired party
(I have a priority call for _____, please)
(4) Operator pushes Priority switch
(5) Operator keys number
(1) Operator pushes Call Advance switch

Priority Pre-emption Call (PP)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired party
(I have a priority call for _____, please)
(4) Operator pushes Priority switch
(5) Operator keys number
(6) Operator and Subscriber receive busy tone; Pre-empt lamp lights
(7) Operator pushes Pre-empt switch
(1) Operator pushes Call Advance switch

Priority Busy Call (PB)

(1) Operator pushes Call Advance switch
(2) Operator gives switchboard designator
(3) Subscriber indicates desired party
(I have a priority call for _____, please)
(4) Operator pushes Priority switch
(5) Operator keys number
(6) Operator and Subscriber receive busy tone; Pre-empt lamp flashes
(7) Operator notices desired party is priority busy and says
(Sir, _____ is in a priority call now; what is the precedence of your call?
(8) Subscriber says
(My precedence is _____)
(9) Operator pushes Interrogate switch and says
(This is the operator, sir; I have a priority call with precedence _____ for _____; what is the precedence of this call?)
(10) Subscriber says
(Our precedence is _____)
(11) If new call is of higher precedence, operator says
(Thank you, sir, I'll have to Pre-empt this call and connect you later)
a. Operator pushes Interrogate switch
b. Operator pushes Pre-empt switch
(12) If new call is of equal or lower precedence, operator says
(Thank you, sir, continue with your call)

a. operator pushes Interrogate switch
b. Operator says to call party
(Sir, the call in process is of a higher precedence; please call later)
c. Subscriber says
(Thank you)

(1) Operator pushes Call Advance switch

APPENDIX B

SWITCH NETWORK ENVIRONMENT

With the necessary switch code names established, line/trunk termination designator assignments were made according to current communications' employment doctrine and considerations generated through field experience. Termination number assignments involved circuit status planning and the switchboard-simulator numbering code (which are discussed in Appendix C). The primary means used during testing to identify subscribers was by termination number. Trunk groups were identified primarily by code designator.

Directory Lists: Alphabetical directory lists were prepared (Tables 1B, 2B) of the line/trunk designator assignments to be used by the operator in Information Calls and as an alternate method to the trunking diagrams for determining trunk-group number assignments. Note that in Table 2B, the directory list was spread over four pages to test the effect of conducting information search in a multiple-paged directory. This directory was the principle difference between the 50 and 100 Tests, since in the former, all information was displayed on one visible surface. It should be noted that in both the 50 and 100 tests, the number of terminations shown seems to be less than required. Actually, this is because each trunk group is only represented by one number though it really consists of several terminations. This is because of the capability in the AN/TTC-15M to conduct automatic line group search.

Trunking Diagrams: According to standard operating procedures, code names for each of the principal divisional units, adjacent elements and higher commands were established.

The division was given the code name of LIMA and units within the division were then further designated by a number (i.e., division main switchboard's code name was LIMA 51). The adjacent divisions to the left and right were designated as PORT and ROAD respectively. Corps was given the code name of CHIP.

As the diagrams show (Figs. 1B, 2B), no alternate routing scheme was considered for the principal reason that simulating alternate routing calls in the tests would reduce the sample sizes of calls more than could be tolerated.

Test Schedules: After the call-processing procedures had been established and a switching network designed, test schedules were prepared for the following purposes:

a. To serve as a script for those acting as subscribers,

b. To serve as a score sheet for the test monitor in marking the subject/operator's errors.

TABLE 1B

Directory List for 50/50LB Tests

Designator	Number	Designator	Number
AID STA	472	HQ CMDT	116
ALO	326	KEYSENDER	247
ARTY LNO	329	LIMA 51	136
AUTOVON	247	LIMA 52	133
BASE	257	LIMA 54	132
BN, 1st	145	LIMA 124	140
BN, 2nd	143	LIMA 126	139
BN, 3rd	141	LIMA 178	113
BN - 3 NET	171	LIMA 206	141
BDE, 1st	140	LIMA 216	143
BDE. 3rd	139	LIMA 226	145
CHAP	325	LNO TENT	109
CO	470	MSG CTR	411
CO TENT	473	MESS	323
COMMO	477	MTR POOL	122
DIAL	257	RAD RELAY	121
DIV ALT	133	SEC	117
DIV MAIN	136	SMAJ	107
DIV - 3 NET	475	S-1 REP	101
DIV SPT	132	S-2	472
ENGR LNO	330	S-3	473
EXEC O	105	S-3 AIR	474
FASE, 2nd	113	S-3 OPNS	128
HEL PAD	308	S-4 REP	104
		XO	405

TABLE 2B

Directory List for 100 Test

Page 1		Page 2		Page 3		Page 4	
Designator	Number	Designator	Number	Designator	Number	Designator	Number
ADC	125	ENGR BN	181	LIMA 52	151	M1 DET	104
AG	110	ENGR REP	177	LIMA 53	156	MSG CTR	132
ARTY LNO	121	FASE, 1st	164	LIMA 54	161	MTR POOL	128
AUTOVON	256	FASE, 2nd	168	LIMA 110	179	NCO MESS	126
AVN BN	140	FASE, 3rd	154	LIMA 124	184	O MESS	101
BASE	266	G-1 REP	111	LIMA 125	188	PLT LDR	107
BDE, 1st	184	G-2	112	LIMA 126	192	PM	109
BDE, 2nd	188	G-3	114	LIMA 154	147	PORT 51	196
BDE, 3rd	192	G-3 AIR	176	LIMA 166	140	PROT CHAP	138
CATH CHAP	136	G-3 OPNS	115	LIMA 167	181	RED CROSS	271
CBR	172	G-4	117	LIMA 177	164	ROAD 51	198
CG	130	G-4 DAO	178	LIMA 178	168	SEC	139
CG TENT	171	G-4 TRANS	119	LIMA 179	154	SIG BN	179
CHIP 144	142	HEL PAD	173	LNO	123	SIG S-3	175
CO	142	HQ CMDT	102			TASE	170
C/S	174	HQ CO	127			TEL I & R	106
DIAL	266	JEW CHAP	137				
DIV ALT	151	KEYSENDER	256				
DIVARTY	147						
DIV MN LEFT	196						
DIV MN RIGHT	198						
DIV REAR	156						
DIV SPT	161						
DSO	108						

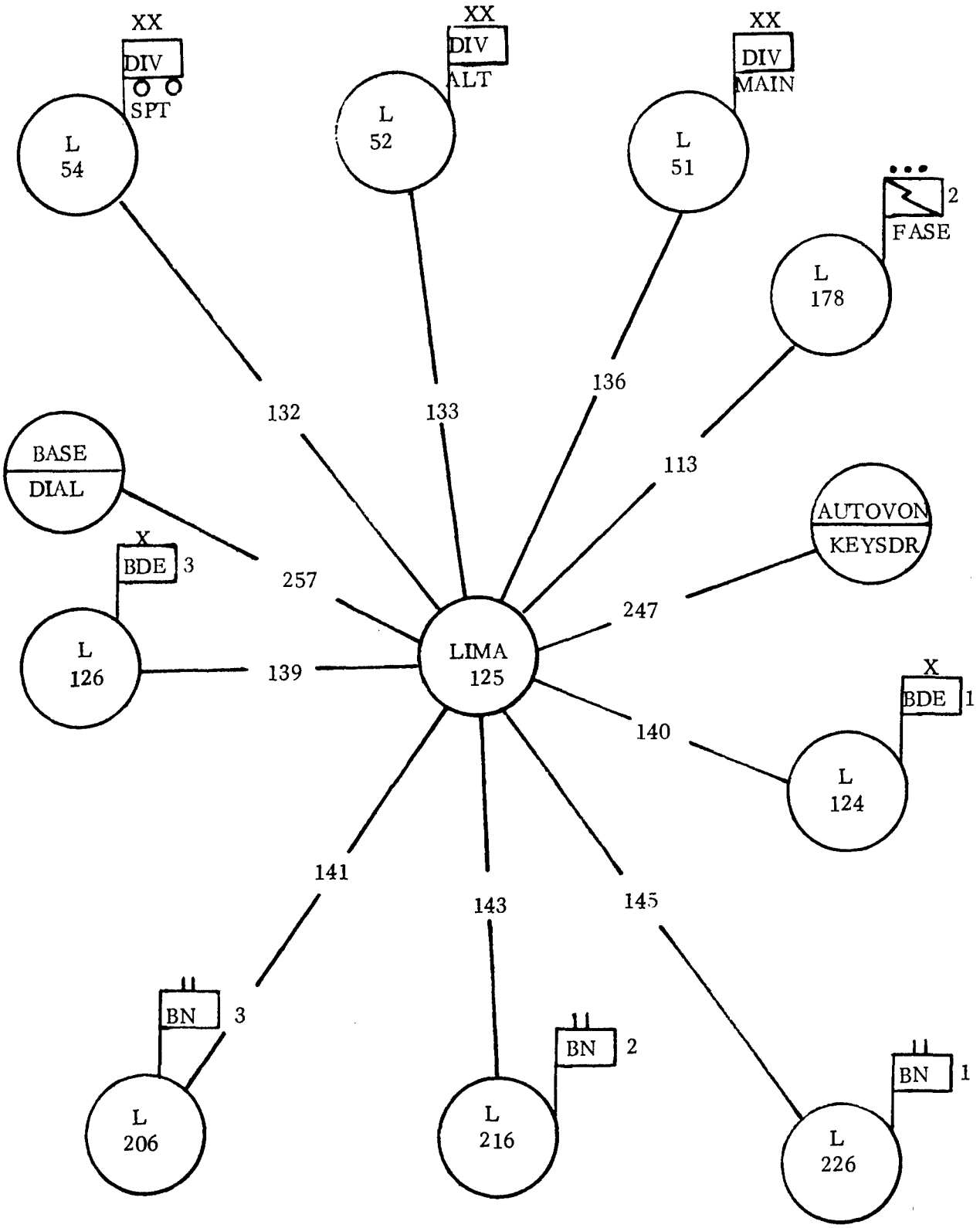

Fig. 1B. TRUNK ROUTING DIAGRAM FOR 50 & 50 LB TESTS

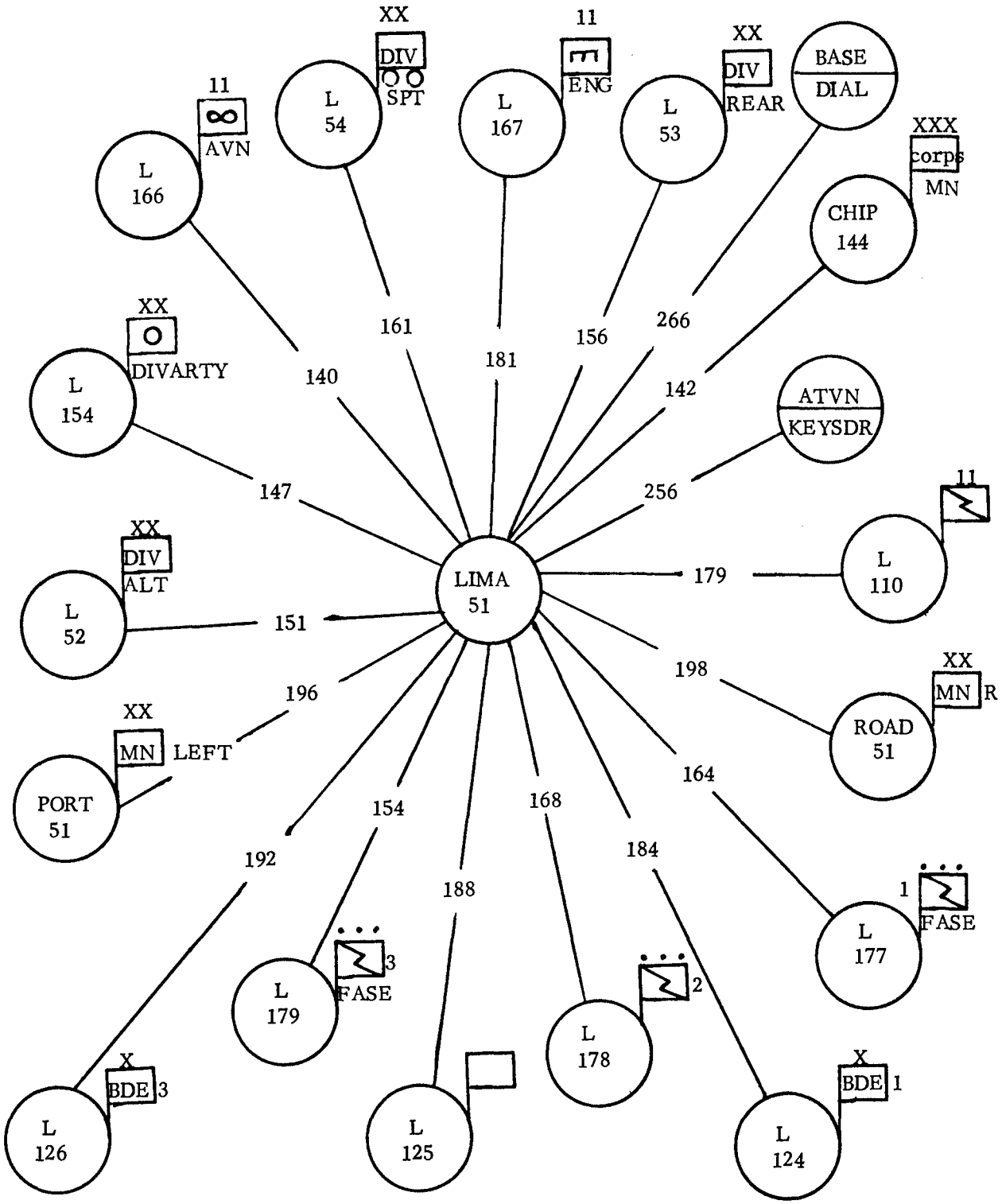

Fig. 2B. TRUNK ROUTING DIAGRAM FOR 100 TEST

c. To provide an initial data-collection sheet for average call-handling times.

The test schedule forms (Figs. 3B-5B) all followed the same format. At the top of the page is a space for the subject's name and the test date. The 50 calls are set off in a 10 x 5 square matrix. Within each square is the following information:

a. Call type

b. Called party

c. Priority designation for P, PB, and PP calls

d. Levels of precedence of the calling called parties in a PB call

e. Calling party (set in ( )) for a C call

f. Trunk-group line number (set in ( )).

The bottom of the form provided space for comments and call-processing time compilation.

1	2	3	4	5	6	7	8	9	10
N L52 (133)	NB 171	D 676-3713 (257)	P P105	NB 472	N - LB 308	I DIV ALT (133)	N L126 (139)	PP P473	D 676- 5199 (257)
N 117	PP P472	PB P474 F-I	N 121	I S4 REP (104)	P P128	K 278-3948 (247)	P - LB P330	N - LB 326	I MTR POO (123)
C 104 105 116	NB 477	K 278-6680 (247)	N 107	PB P473 1 - E	N-LB 323	N - LB 329	P P141	N 104	N 128
PP P471	P P105	D 676-2504 (257)	C 107 117 128	N L226 (145)	I RAD REL (121)	I SEC (117)	PB P473 E - F	NB 475	N 101
K 278-8913 (247)	NB 472	I HQ CMDT (116)	N 430	C LB 109 326 128	N L124 (140)	N - LB 323	I 3rd BDE (139)	N 117	N - LB 326

N _____ 23
C _____ 3
K _____ 3
D _____ 3
I _____ 7
P _____ 5
PP _____ 3
PB _____ 3

Fig. 3B. 50 LB TEST SCHEDULE

	1	2	3	4	5	6	7	8	9	10
	N L52 (133)	NB 171	D 676-3713 (257)	P P105	NB 472	N -LB 308	I DIV ALT (133)	N L126 (139)	PP P473	D 676- 5199 (257)
11-	N 117	PP P472	PB P474 F - I	N 121	I S4 REP (104)	P P128	K 278-3948 (247)	P - LB P330	N - LB 326	I MTR POOL (123)
21-	C 104 105 116	NB 477	K 278-6680 (247)	N 107	PB P473 I - E	N - LN 323	N - LB 329	P P141	N 104	N 128
31-	PP P471	P P105	D 676-2504 (257)	C 107 117 128	N L226 (145)	I RAD REL (121)	I SEC (117)	PB P473 E - F	NB 475	N 101
41-	K 278-8913 (247)	NB 472	I HQ CMDT (116)	N 430	C LB 109 326 128	N L124 (140)	N - LB 323	I 3rd BDE (139)	N 117	N - LB 326

N _____ 23
C _____ 3
K _____ 3
D _____ 3

I _____ 7
P _____ 5
PP _____ 3
PB _____ 3

Fig. 4B. AN/TTC-15M - 50 TEST SCHEDULE

	1	2	3	4	5	6	7	8	9	10
	N 108	NB 178	D 676-3711 (266)	P P117	NB 174	N 110	I SEC (139)	N 138	PP P171	D 676- 7113 (266)
11-	N C144 (142)	PP P173 F - I	PB P178	N 136 (104)	I MI DET (104)	P PL54 (161)	K 278-3712 (256)	P PL54 (161)	N L154 (147)	I CORPS MAIN (142)
21-	C 102 107 127	NB 177	K 278-5614 (256)	N L166 (140)	PB P178 I -E	N 119	N 139	P P114	N L54 (161)	N L179 (154)
31-	PP PL110	P PL53 (156)	D 676-6187 (266)	C 114 117 125	N 151	I AG (110)	I O MESS (101)	PB P178 E - F	NB 171	N L53 (156)
41-	K 278-4780 (256)	NB 174	I ARTY LNO (121)	N 106	C 102 107 127	N 101	N 114	I CATH CHAP (136)	N 109	N L53 (156)

N 18 NB 5 C 3 K 3 D 3 I 3 P 5 PP 3 PB 3

Fig. 5B. 100 TEST SCHEDULE FOR AN/TTC-15M - 100 TEST

APPENDIX C

AN/TTC-15M SWITCHBOARD SIMULATOR

The switchboard simulator consists of two main components, the switchboard console and remote-control unit. The internal circuitry of the simulator will not be disclosed, in respect to the property rights of the contractor. The functions performed by each during testing, however, are described in the following break-down of component elements:

SWITCHBOARD CONSOLE (FIGURE 1C)

1. Power Group: non-functional

2. Night Alarm: non-functional

3. Calls In Process Group: non-functional

4. Maintenance Group: non-functional

5. Information Display: Consists of alphabetical directory list and trunk-routing diagram for both brigade and division main-switch locations; these displays are mounted on cardboard and hinged to expedite search.

6. Conference Group: When moved to the "TALK" position the toggle switch lights the top lamp to indicate the conference-call originator has been transferred to the conference link. When moved to the "Norm" position, the toggle switch extinguishes all lamps to indicate the conference link is idle (a Conference-Busy call is not included in the tests). Second, third and fourth lamps are activated by the remote-control unit. (See Remote Control Unit 1, 2 and 3 following.) Fifth lamp is non-functional, since only a four-party conference was simulated.

7. "Calls Waiting" Number Display: The number displayed automatically drops one unit when the Service Request switch below is pushed to indicate a reduction in the number of calls waiting in queue. Controlled by the remote-control unit, the number display automatically increases one unit every 10 seconds to nine, the maximum number displayed.

8. Service Request Switch: The switch is split into two sections; the top section marked, "SER REQ," and the lower section marked, "Connected." The service-request section remained lit throughout the testing sequence to indicate a continuous imput of call request. The connected section remained lit unless the Interrogate, Operator Originate Call, or Calling Release switches were used, indicating that the operator was no longer connected to the Service Request queue. The switch is also connected to the event recorder and causes a mark on the recording paper when pushed.

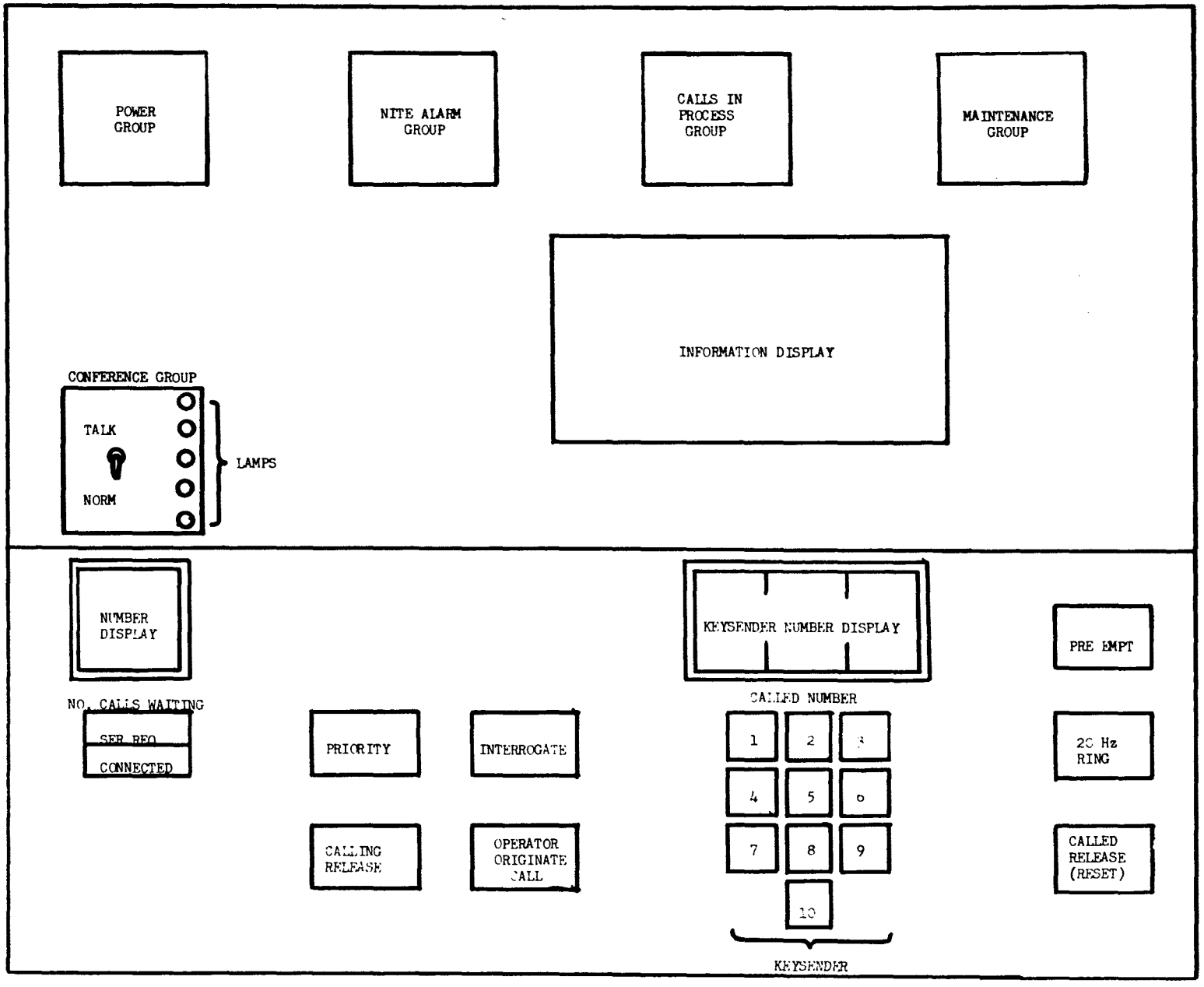

Fig. 1C. SWITCHBOARD CONSOLE

9. The Priority Switch lights up when pushed to indicate a priority mark condition and extinguishes when the Service Request Switch is activated.

10. The Interrogate Switch alternately lights/extinguishes when pushed. While the switch is lit, the connect section of the Service Request Switch is unlit.

11. The Calling Release Switch was not used during testing.

12. The Operator Originate Call Switch was not used during testing.

13. The Keysender Number Display displays the first three numbers keyed until extinguished by the operator pushing the Service Request Switch to go on to the next call waiting in the queue.

14. The Keysender uses the numbering code incorporated into the switchboard simulator by the contractor and obtains the responses shown in Table 1C. A comparison of this numbering code to the termination assignments shown in Tables 2 and 3 shows that certain terminations were designed to remain in a busy/priority busy condition throughout testing.

15. The Pre-empt Switch with the priority switch pushed and an X7X number keyed, will light to indicate PP call conditions. With the Priority Switch pushed, and X7X number keyed, and the Busy Flash Switch (Remote Control Unit on, the switch lamp will flash to indicate PB call conditions. The Pre-empt Switch can be extinguished by pushing either the Service Request Switch or the Pre-empt Switch itself.

16. The 20 Hz Ring Switch lamp is activated whenever a 3XX number is keyed to indicate a Local Battery condition. Each time the lit switch is pushed, it produces a ring signal to simulate additional rings to the called party. The lamp is extinguished by the operator pushing the Service Request Switch to go on to the next calling party in queue.

17. The Called Release (Reset) Switch erases any numbers shown in the Keysender Number Display and stops any tone signal.

REMOTE CONTROL UNIT (FIGURE 2C)

1. The Conference Switches turn on/off the indicated conference group lamp (see switch console, F., preceding).

2. The Busy Flash Switch, in the "ON" position, causes the Pre-empt Switch on the switchboard console to flash when an X7X number is keyed.

3. The Called Release Switch, an extension of the Called Release (Reset) Switch on the switchboard console, allows the Remote Control attendant to cancel the ring signal

TABLE 1C

Switchboard Simulator Numbering Code

Number Code	Response	Use
1XX	Multiple Ring Signal	N Calls
2XX	Dial Tone	D & K Calls
3XX	Single Ring Signal; 20 Hz Ring	All Local Battery Calls
4XX-9XX	None	
X7X	Busy Signal	NB, PP, PB Calls

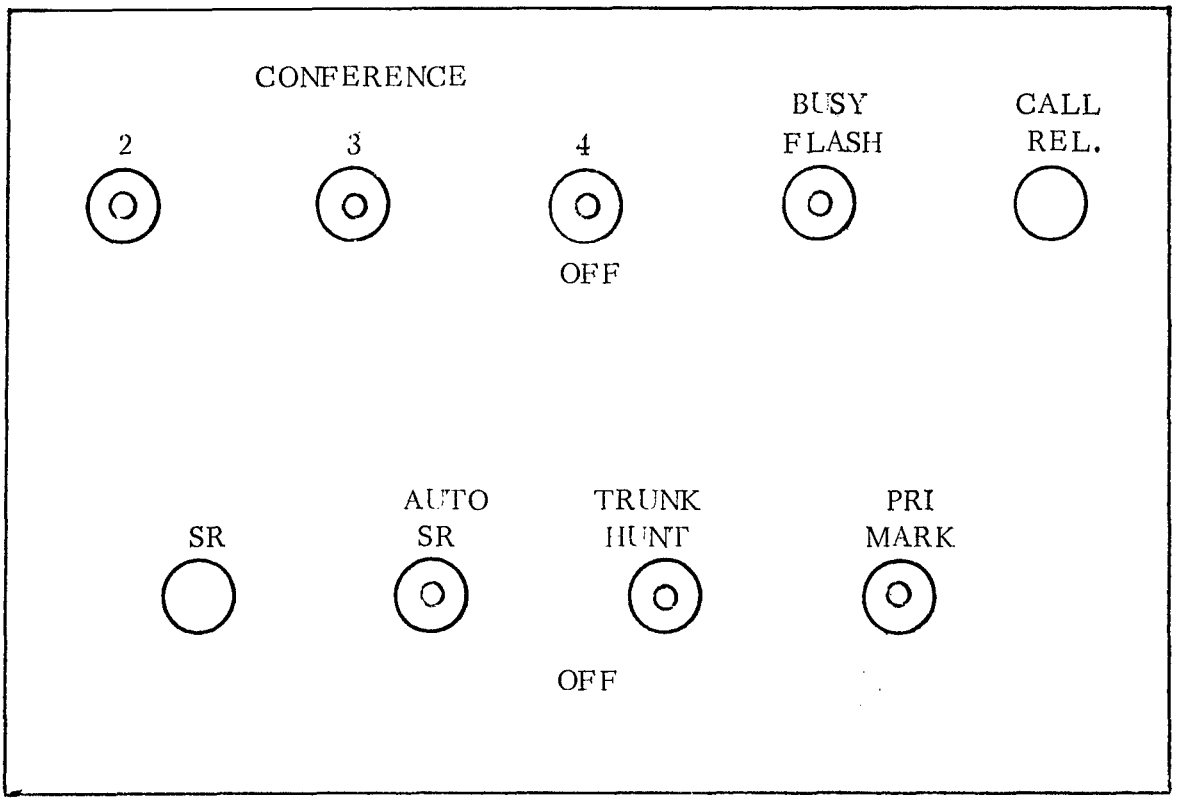

Fig. 2C. REMOTE CONTROL UNIT LAYOUT

during a Conference call to simulate to conferee's telephone going off-hook.

4. The Service Request Switch (SR) adds one unit in the "Calls Waiting Number Display" each time it is pushed. It was not used during testing.

5. The Automatic Service Request Switch (AUTO SR), when in the "ON" position, adds one unit automatically every 10 seconds in the "Calls Waiting" Number Display.

6. The Trunk Hunt Switch, in the "ON" position, causes 2XX numbers keyed to step four units in simulating trunk search.

7. The Priority Mark Switch (PRI MARK) in the "ON" position, causes the "SER REQ" section of the Service Request switch on the switchboard console to flash, indicating an incoming priority marked call. It was not used during testing.

APPENDIX D

AN/TTC-15M FUNCTIONAL TIME STUDY QUESTIONNAIRE

GENERAL

Name _____

Rank _____

Serial Nr. _____

MOS _____ Job Title _____

Nr of Years in Army _____

Years Previous Experience with Switchboards _____

Where? _____

If Experienced, what Switchboard? _____

Height _____ Weight _____

CALL HANDLING PROCEDURES

1. Do you feel you understand the call procedures? (Yes) (No) _____

2. The call handling procedures are listed below; indicate your opinion on each of the procedures by checking the appropriate lines.

	I found the procedures to be:	
a. Normal Call Extend:	____easy to conduct ____moderately easy to conduct ____moderately difficult to conduct ____very difficult to conduct	____easy to remember ____moderately easy to remember ____moderately difficult to remember ____very difficult to remember
b. Priority Call Extend:	____easy to conduct ____moderately easy to conduct ____moderately difficult to conduct ____very difficult to conduct	____easy to remember ____moderately easy to remember ____moderately difficult to remember ____very difficult to remember
c. Priority Call Extend--Pre-emption Required	____easy to conduct ____moderately easy to conduct ____moderately difficult to conduct ____very difficult to conduct	____easy to remember ____moderately easy to remember ____moderately difficult to remember ____very difficult to remember
d. Priority Call Extend--Call Party Priority Busy; Precedence Determination Required:	____easy to conduct ____moderately easy to conduct ____moderately difficult to conduct ____very difficult to conduct	____easy to remember ____moderately easy to remember ____moderately difficult to remember ____very difficult to remember

e. Keysender Call Extend:

____ easy to conduct	____ easy to remember
____ moderately easy to conduct	____ moderately easy to remember
____ moderately difficult to conduct	____ moderately difficult to remember
____ very difficult to conduct	____ very difficult to remember

d. Dial Call Extend:

____ easy to conduct	____ easy to remember
____ moderately easy to conduct	____ moderately easy to remember
____ moderately difficult to conduct	____ moderately difficult to remember
____ very difficult to conduct	____ very difficult to remember

3. If you found any call handling procedure to be difficult, what would you do to correct it? _____

_____

_____

4. (a) Do you think that this is better than operating on the SB-86 switchboard currently used in the Army? (Yes) (No)___Explain _____

_____

_____

(b) Do you think that this is better than operating the SB-3082 Switchboard currently under design for the Army? (Yes) (No) _____Explain_____

_____

_____

5. Do you have any other comments about operating this switchboard?_____

_____

_____

_____

_____

_____

SWITCHBOARD LAYOUT

1. Some of the controls and displays used on the front panel are listed below; indicate your opinion on each by checking the appropriate line(s).

a. Lighted push-button switches (general comments)

I found manipulation of the control to be:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

I found the control/display _____ to find and see:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

b. Numerical displays (general comment)

I found manipulation of the control to be:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

I found the control/display _____to find and see:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

c. Keysender Group

I found manipulation of the control to be:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

I found the control/ display _____to find and see:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

d. Call Advance Group

I found manipulation of the control to be:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

I found the control/display _____to find and see:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

e. Call Release (reset)

I found manipulation of the control to be:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

I found manipulation of _____to find and see:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

f. Preempt

I found manipulation of the control to be:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

I found manipulation of _____to find and see:
_____easy
_____moderately easy
_____moderately difficult
_____difficult

g. Interrogate	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult
h. 20HZ Ringdown Circuit	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult
i. Calling Release	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult
j. Priority	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult
k. Operator Originate Call	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult
l. Calls In Progress	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult

m. Conference Group	I found manipulation of the control to be: _____easy _____moderately easy _____moderately difficult _____difficult	I found the control/display _____to find and see: _____easy _____moderately easy _____moderately difficult _____difficult

NOTE: If you marked any control or display as either moderately difficult or difficult to manipulate or to see, explain the difficulty:_____

_____

_____

_____

2. The different functional groups are listed below; indicate your opinion on each by checking the appropriate line(s).

	General Position of Group on Fron Panel:	Arrangement of Functions Within Group:
a. Power Group:	_____Poor _____Fair _____Good	_____Poor _____Fair _____Good
b. Nite Alarm:	_____Poor _____Fair _____Good	_____Poor _____Fair _____Good
c. Calls in Process Group	_____Poor _____Fair _____Good	_____Poor _____Fair _____Good
d. Maintenance:	_____Poor _____Fair _____Good	_____Poor _____Fair _____Good
e. Information Display	_____Poor _____Fair _____Good	_____Poor _____Fair _____Good
f. Call Advance:	_____Poor _____Fair _____Good	

	General Position of Group on Front Panel:	Arrangement of Functions Within Group:
g. Keysender:	_____Poor _____Fair _____Good	
h. Conference Group:	_____Poor _____Fair _____Good	_____Poor _____Fair _____Good
i. Operator Originate Switch	_____Poor _____Fair _____Good	
j. Preempt Switch	_____Poor _____Fair _____Good	
k. Interrogate Switch	_____Poor _____Fair _____Good	
l. Calling Release Switch	_____Poor _____Fair _____Good	
m. Called Release Switch	_____Poor _____Fair _____Good	
n. 20HZ Ring Switch	_____Poor _____Fair _____Good	

NOTE: If you marked any functional group as poor, explain why:_____

_____

_____

_____

APPENDIX E

ERROR MASTER DATA SHEETS

Table 1E presents the basic results by type error. In column 1, the error types are grouped into five categories:

1. Errors common to all calls (this type of error would occur regardless of call type) (NORMAL)

2. Errors common to Dial/Deysender calls: (D/K)

3. Errors common to Conference calls: (C)

4. Errors common to Information calls: (I)

5. Errors common to Priority calls (this includes P, PP and PB calls): (P)

Columns 2 and 3 give the number of errors made and identifies the Recall/Delay classification assigned to each type error. Definitions of these two classifications are given in the Results & Discussion Section.

Table 2E presents the operator-error distribution by test and by subject. With each test errors are grouped into the five categories (Common, D/K, C, I, P). Except for the base lines, figures are NUMBER OF RECALLS/NUMBER OF DELAYS. Base lines show number of calls handled per group. The number was computed by reducing the total calls possible per group by the test faults per group. (Test faults were calls in the test removed from the data analysis due to no fault of the Subject/operators.)

TABLE 1E

TYPE ERROR DISTRIBUTION

TYPE ERROR	CLASSIFICATION RECALL	DELAY
ERRORS COMMON TO ALL CALLS: (NORMAL)		
1. Started to key wrong number but corrected		7
2. Keyed wrong number	3	
3. Hit Call Advance switch twice (skipped call in queue)	1	
SUB TOTAL	4	7
ERRORS COMMON TO DIAL/KEYSENDER CALLS (D/K)		
1. Started to key wrong number but corrected		2
SUB TOTAL		2
ERRORS COMMON TO CONFERENCE CALLS: (C)		
1. Left Conference switch in "Talk" position after completing Conference call process		1
2. Initially forgot to put conference switch in "Talk" position		1
SUB TOTAL		2
ERRORS COMMON TO INFORMATION CALLS: (I)		
1. Gave wrong information	2	
2. Forgot to give number		2
SUB TOTAL	2	2
ERRORS COMMON TO PRIORITY CALLS: (P)		
1. Established wrong priority		6
2. Failed to mark priority but corrected		1
SUB TOTAL		7
COMPOSITE TOTAL	6	20

TABLE 2E

ERROR DISTRIBUTION BY TEST

	50LB TEST	50 TEST					100 TEST				
	LB	Normal	D/K	C	I	P	Normal	D/K	C	I	P
A	0	1/0	0/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0
B	0	0/1	0/0	0/0	0/0	0/1	1/1	0/0	0/0	0/0	0/1
C	0	0/0	0/0	0/0	0/0	0/2	0/0	0/1	0/0	**0/0**	0/0
D	0	0/0	0/0	0/0	0/0	0/0	0/1	0/0	0/0	0/0	0/0
E	0	0/0	0/0	0/0	0/0	0/0	1/1	0/0	0/0	0/0	0/1
F	0	0/0	0/0	0/0	1/0	0/1	0/1	0/0	0/0	0/0	0/0
G	0	0/1	0/0	0/0	1/2	0/0	0/0	0/0	0/0	0/0	0/0
H	0	0/1	0/1	0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0
I	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/1	0/0	0/1
BASE	72	427	53	25	56	92	422	50	26	62	85

NOTE:

LB	=	Failure to note a local-battery call
NORMAL	=	Errors common to all calls
C	=	Errors common to Conference calls
P	=	Errors common to Priority calls
D/K	=	Errors common to Dial or Keysender calls
I	=	Errors common to Information calls

Figures in Normal, D/K, C, I, and P columns indicate number of recalls/ number of delays.

APPENDIX F

QUESTIONNAIRE RESPONSE

CALL PROCESSING PROCEDURES

1. All nine subjects questioned felt they understood the call processing procedures.

2. Procedure opinion ratings:

I found the procedure to be:

	Response:	Response:
a. Normal Call Extend:	9 easy to conduct	9 easy to remember
	0 moderately easy to conduct	0 moderately easy to remember
	0 moderately difficult to conduct	0 moderately difficult to remember
	0 very difficult to conduct	0 very difficult to remember
b. Priority Call Extend:	7 easy to conduct	6 easy to remember
	2 moderately easy to conduct	3 moderately easy to remember
	0 moderately difficult to conduct	0 moderately difficult to remember
	0 very difficult to conduct	0 very difficult to remember
c. Priority Call Extend-- Pre-emption Required:	8 easy to conduct	6 easy to remember
	1 moderately easy to conduct	3 moderately easy to remember
	0 moderately difficult to conduct	0 moderately difficult to remember
	0 very difficult to conduct	0 very difficult to remember
d. Priority Call Extend-- Called Party Priority Busy; Precedence Determination Required:	7 easy to conduct	5 easy to remember
	2 moderately easy to conduct	4 moderately easy to remember
	0 moderately difficult to conduct	0 moderately difficult to remember
	0 very difficult to conduct	0 very difficult to remember

	Response:	Response:
e. Keysender Call Extend:	9 easy to conduct	8 easy to remember
	0 moderately easy to conduct	1 moderately easy to remember
	0 moderately difficult to conduct	0 moderately difficult to remember
	0 very difficult to conduct	0 very difficult to remember
f. Dial Call Extend:	9 easy to conduct	8 easy to remember
	0 moderately easy to conduct	1 moderately easy to remember
	0 moderately difficult conduct	0 moderately difficult remember
	0 very difficult to conduct	0 very difficult to remember

3. Call processing procedure comments:

a. Two individuals felt that some method of also displaying dial and keysender numbers should be provided.

b. One individual felt that there should be some means of placing called conference parties on hold so as not to interfere with the operator while he is trying to complete calling the other conferees.

c. All nine preferred operating on the AN/TTC-15M to the SB-86/PT currently used in the Army. The general reason given for this preference was that the call processing procedures on the AN/TTC-15M are much easier to remember and no plug supervision was required.

SWITCHBOARD LAYOUT

1. Control/Display Opinion Ratings:

	I found manipulation of the control to be:	I found the control/display ___ to find and see;
a. Lighted pushbutton switches (general comment)	Response:	Response:
	8 easy	8 easy
	1 moderately easy	1 moderately easy
	0 moderatel difficult	0 moderately difficult
	0 difficult	0 difficult

b. Numerical displays	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	9 easy	9 easy
	0 moderatley easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult
c. Keysender Group	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	8 easy	9 easy
	1 moderately easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult
d. Call Advance Group	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	7 easy	7 easy
	2 moderately easy	2 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult
e. Call Release(reset)	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	9 easy	9 easy
	0 moderately easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult
f. Preempt	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	9 easy	9 easy
	0 moderately easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult

g. Interrogate	I found manipulation of the control to be:	I found the control/display ___ to find and see :
	8 easy	8 easy
	1 moderately easy	1 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult

h. 20 Hz Ringdown Circuit	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	9 easy	9 easy
	0 moderately easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult

i. Calling Release - Not used during testing.

j. Priority	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	9 easy	9 easy
	0 moderately easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult

k, Operator Originate Call - Not used during testing.

l. Calls In Progress - Not used during testing.

m. Conference Group	I found manipulation of the control to be:	I found the control/display ___ to find and see:
	6 easy	9 easy
	3 moderately easy	0 moderately easy
	0 moderately difficult	0 moderately difficult
	0 difficult	0 difficult

2. Funtional Groups Opinion Rating

	General Position of Group on Front Panel:	Arrangement of Functions Within Group:

	Response:	Response:
a. Information Display:	0 Poor	0 Poor
	3 Fair	4 Fair
	6 Good	5 Good
b. Call Advance:	0 Poor	
	2 Fair	
	7 Good	
c. Keysender:	0 Poor	
	0 Fair	
	9 Good	
d. Conference Group:	1 Poor	0 Poor
	2 Fair	4 Fair
	6 Good	5 Good
e. Operator Originate Switch:	0 Poor	
	2 Fair	
	7 Good	
f. Preempt Switch:	0 Poor	
	1 Fair	
	8 Good	
g. Interrogate Switch	0 Poor	
	0 Fair	
	9 Good	
h. Calling Release Switch	0 Poor	
	0 Fair	
	9 Good	
i. Called Release Switch	0 Poor	
	0 Fair	
	9 Good	
j. 20Hz Ring Switch	0 Poor	
	0 Fair	
	9 Good	

3. Control/Display Comments: The individual who gave the poor rating on the general position of the Conference group on the front panel explained his rating by commenting that the group should be located below with the other principal call-processing elements.

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This report covers the second in a series of studies directed towards analyzing the operator call-processing efficiency of a new family of cordless manual switchboards currently within the Army's inventory. Subjects were required to process a battery of 50 simulated calls of various types in each mode of operation. Call-processing time and operator error were measured and later integrated into actual tactical telephone traffic data for analysis.

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